Reviewing Nordic transport challenges and climate policy priorities: expert perceptions of decarbonisation in Denmark, Finland, Iceland, Norway, Sweden

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Abstract: The five Nordic countries of Denmark, Finland, Iceland, Norway and Sweden have aggressive climate and energy policies in place and are largely on track in their decarbonisation of electricity, heat, and buildings. Transportation and mobility, however, remains a pressing challenge. This study asks: what are the greatest national and regional transport challenges facing Nordic countries? To provide an answer, the authors conducted 227 semi-structured interviews with participants from 201 institutions across seventeen cities within the Nordic region. Those interviewed represent a diverse array of stakeholders involved with transport technology, policy and practice. Although respondents identified 44 distinct transport challenges, the fossil fuel intensity of transport was by far the most frequently mentioned by than two-fifths (42%) of the expert sample. Five other challenges were also mentioned the most frequently by respondents: long travel distances (17%), the state of public transport infrastructure (16%), congestion (15%), population density (10%), and electrification of transport (10%). Interestingly, items such as costs and affordability, energy or transport efficiency, consumer knowledge and awareness, and automobile accidents were mentioned by only 3% (or less). The article concludes by what this heterogeneity and prioritization of challenges means for future Nordic research and policy.

1. Introduction

Transportation and mobility use significant amounts of energy, and those sectors account for a substantial amount of greenhouse gas emissions and other energy-related externalities (Pan et al. 2018; Sonmez et al. 2017; Mohammadi and Taylo 2017; Zhang et al. 2011; Flórez-Orrego et al. 2015; Malla 2014; Ridjan et al. 2014; Usón et al. 2011). Also, the electrification of passenger transport (the merging of energy and transport systems) offers many opportunities and is an emerging but core theme in this journal. Research has shown for instance that electric mobility can lead to more resilient cities (Comodi et al. 2016) or reduce negative externalities such as pollution (Noel et al. 2018). When connected to the grid, electric vehicles can enhance the efficiency of distribution networks (Pirouzi et al. 2018), contribute positively to grid stabilization (Nunes and Brito 2017), and act as decentralized modes of energy storage (Weiller and Neely 2014). Electric vehicles can lastly become key components of 100% “smart” or “clean” renewable energy systems (Mathiesen et al. 2015; Connolly et al. 2014; Mathiesen et al. 2011).

For reasons such as these, the Nordic region is known for having some of the most consistent and progressive policies for decarbonizing transport, electricity, buildings, and industry, and Nordic countries have emerged to become global leaders in technological areas such as renewable electricity supply or the adoption of energy efficiency technologies and practices (Sovacool 2017). For example, Denmark is renowned for its pioneering use of wind energy, Finland and Sweden bioenergy, Norway hydroelectricity and Iceland geothermal energy. All countries aim to be virtually "fossil free" by 2050. Indeed, as the International Energy Agency and Nordic Energy Research (2016: 8) note, electricity generation across the Nordic region is 87% "carbon-free" and the regional economy has "exhibited a steady decoupling of GDP from energy-related CO2 emissions and declining CO2 intensity in energy supply for decades."

However, the single, most important policy challenge facing the region in terms of meeting its carbon policy targets is perhaps decarbonisation of the transport sector. As the International Energy Agency (2013: 99) concluded, "the transport sector contributes to more than one-third of energy-related carbon dioxide (CO2) emissions in the Nordic countries." Over the previous decades, engineers and regulators have proposed natural gas powered cars, hybrid-electric vehicles, vehicle-to-grid systems, flex-fuel automobiles, hydrogen fuel cells, ethanol, second-generation biofuels, coal to liquids, tar sands, oil shale, and a host of other alternative fuels and modes as necessary to either diversify forms of mobility or promote cleaner or more affordable forms of transport (Sovacool 2007).

Despite this great diversity and variation in mobility options, the future of transport and mobility options across the Nordic region remains contested. Some suggest that hydrogen fuel cells represent an optimal way to shift away from internal combustion engines, but stakeholders remain deeply divided over hydrogen research pathways (Andreasen et al. 2015; Enevoldsen et al. 2014). An aggressive expansion of advanced biofuel may be necessary, but raises concerns over land use and transport (Fevolden et al. 2017; Fischer et al.

2010). Needed investments in electric vehicles and associated charging infrastructure must also occur (Borén e al. 2017; Graabak et al. 2016; Noel et al. 2016), but may not be financially viable in the short-term.

This study asks: What are the greatest national and regional transport challenges facing Nordic countries as perceived by experts living within the region? To provide an answer, the authors conducted 227 semi-structured interviews with participants from 201 institutions across seventeen cities in Denmark, Finland, Norway, Iceland, and Sweden. Those interviewed were selected to represent the diverse array of stakeholders involved with transport technology, policy and practice, and included experts from national government ministries, agencies, and departments; local government ministries, agencies, and departments; regulatory authorities and bodies; universities and research institutes; automobile manufacturers and car dealerships; private sector companies; and industry groups and civil society organizations.

We find that those interviewed identified no less than 44 distinct transport challenges facing the Nordic region. By far the most frequently mentioned of these (42% of respondents) was the fossil fuel intensity of transport and mobility. Five other challenges apart from fossil fuel intensity were mentioned the most frequently: long travel distances (17%), the state of public transport infrastructure (16%), congestion (15%), population density (10%), and electrification of transport (10%). After presenting these results, we then conclude by noting what this heterogeneity of challenges means for future Nordic research and policy.

2. Research design: Qualitative expert interviews

To explore the challenges, barriers, and obstacles facing transport and mobility in the Nordic region, the authors relied primarily on original data collected through semi-structured research interviews as part of a broader project looking at electric mobility and vehicle-to-grid (Sovacool et al. 2018a; Sovacool et al. 2018b; Kester et al. 2018a; Kester et al. 2018b).

By *semi-structured interviews*, the authors mean that our data collection involved the asking of semi-structured questions to respondents, sometimes referred to as "expert elicitation," "guided introspection," "intensive interviewing," "responsive interviewing," or soliciting "stated preferences" (O'Sullivan et al. 2010; Yin 2003; Hancke 2009). This technique asks participants a set of fixed questions but then allows the conversation to build and deviate to explore new directions and areas. Such interviews are most appropriate when the research objective is to comprehend complicated programs or events and how they intersect with perceptions, beliefs, and values (Yin 2003). Interviews were also chosen because, unlike documents that can take months or even years to be published, they enabled the collection of recent data that (at the time of the interview) was not yet available in other formats.

The authors conducted 227 semi-structured interviews with more than 250 participants from 201 institutions across 17 cities in the five countries of Denmark, Finland, Iceland, Norway and Sweden from September 2016 to May 2017. Those interviewed were selected to represent the diverse array of stakeholders involved with transport technology, policy and practice, and included members of:

- National government ministries, agencies, and departments including the Ministry of Industries & Innovation (Iceland), Ministry of Transport (Norway), Ministry of Environment and Energy (Sweden), Ministry of Finance (Finland);
- Local government ministries, agencies, and departments including the Akureyri Municipality (Iceland), City of Stockholm (Sweden), Aarhus Kommune (Denmark), City of Tampere (Finland), City of Oslo (Norway), and Trondheim Kommune (Norway);
- Regulatory authorities and bodies including the National Energy Authority (Iceland), Danish Transport Authority, Icelandic Transport Authority, Helsinki

Regional Transport Authority (Finland), Trafi (Finland), and the Norwegian Public Roads Administration;

- Universities and research institutes including the University of Iceland, Swedish Environmental Institute, DTU (Denmark), Aalborg University (Denmark), VTT Technical Research Centre (Finland), NTNU (Norway), and the Arctic University of Norway;
- Automobile manufacturers and dealerships including the BMW Group (Norway), Volvo (Sweden), Nissan Nordic (Finland), Volkswagen (Norway), and Renault (Denmark);
- Private sector companies including Siemens Mobility (Denmark), DONG (Denmark, named after our interviews to Ørsted), Fortrum (Finland), Ramboll (Finland), Norske Hydrogen (Norway), IBM (Norway), Microsoft (Norway) and Schneider Electric (Norway);
- Industry groups and civil society organizations such as the Swedish Power Circle; the Finnish Petroleum and Biofuels Association, Tesla Club (Finland), and the Norwegian Electric Vehicle Association.

Interviews lasted generally between thirty and ninety minutes in their duration, and participants were asked a number of questions, including these two specific to the study: "What do you see as your country's greatest transport challenges?" and "What do you see as the Nordic region's greatest transport challenges?" Participants were not prompted for responses and were permitted to answer as long or as detailed as they wished. Each interview was carefully recorded and then fully transcribed and analyzed. Each interview was also given a unique number (which we refer to whenever presenting interview data – i.e., we reference it by interview, not respondent, since some interviews had multiple respondents).

Admittedly, the nonrandom sample relied upon for primary data is limited in several ways. First, although the interviewees listed in Appendix I come from many disciplines and

organizations, the sample was confined primarily to researchers that spoke English, and to some degree it was moderated by location and knowledge of local context. Furthermore, a fair number of researchers were unavailable for interviews, creating a potential selection bias (only those who said "yes" are included). In summary, this analysis should not be interpreted as representing the full diversity of approaches to expert perspectives on Nordic transport challenges. Rather, it is an analysis of what a nonrandom or 'convenience' sample of leaders of the field, or a network of people with prominent field positions, perceive to be important challenges – creating an illustrative rather than fully representative sketch.

Two other elements of our research design deserve mentioning: anonymity and grounded theory. The data from these interviews is presented here as *anonymous* for multiple reasons. Confidentiality protects respondents from retaliation over divulging potentially controversial information. Also, it can encourage candor, as people often speak their minds if they no longer have to worry about their statements coming back to haunt them. Moreover, although institutional affiliation were relevant for sampling purposes, individuals were not speaking on behalf of their institutions and were instead giving their personal opinion. Although participants were therefore guaranteed anonymity, Appendix I offers a high-level summary of the interview respondents.

Finally, the research was *grounded* in the sense that we commenced our project without any preformed hypotheses. This method is sometimes called "grounded theory" because it is an inductive discovery method that starts with no theoretical preconception. Instead, researchers develop a conceptual account from the "ground up," the analysis grounded in the data collected itself (Geertz 1970; Strauss and Corbin 1990). As an advantage, we did this because we maintain a grounded approach helps minimize interpretative bias caused by researchers trying to force responses into preset cognitive frameworks (Blaikie, 2000, Cook and Campbell, 1979). As a disadvantage, it means that our results below are agnostic about theory and conceptual frameworks – we present our findings

and analysis devoid of any connection to particular academic theories. In addition, some of our results below are not necessarily novel or surprising, they can be considered hypothesis confirming (supporting earlier research) as well as hypothesis generating (leading to new explorative areas) (Sovacool et al. 2018c). Moreover, grounded theory is known producing messy data that is not always coherent, highly dependent on the respondents (the approach will pick up misperceptions alongside accurate perceptions), prone to highly variable or selective coding frameworks, and not always amenable to verification or quantitative replication (Corbin and Strauss 1990; Charmaz 2006; Kelle 2007). Nonetheless, despite these shortcomings it has still been used fruitfully in the energy studies and transport fields, including this journal (Sovacool et al. 2018a; Curkovic et al. 2005) and topics as diverse as energy efficiency organizational behavior (Maiorano 2018), perceptions of energy security (Herhandez 2016), the local acceptance of electricity transmission lines (Galvin 2018), public perceptions of shale gas (Sangaramoorthy et al. 2016), and marine renewable energy (Stokes et al. 2014). This makes it an established approach within the field.

3. Results: Six compelling transport challenges

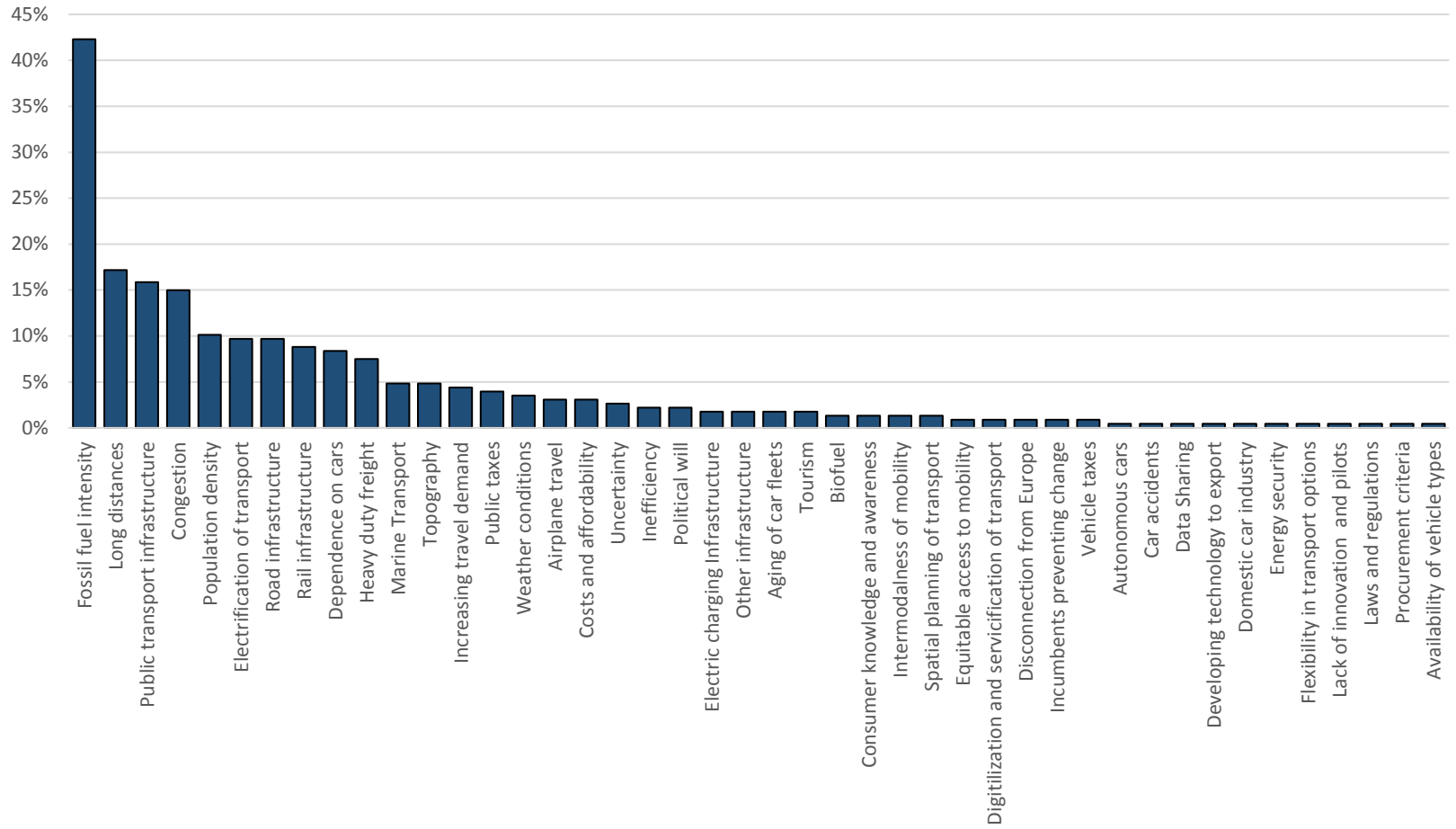
As both Table 1 and Figure 1 summarize, our 227 interview respondents discussed and classified 6 important and 44 total and distinct transport related challenges. When combining results across both questions (national and regional challenges), the most frequently mentioned in order are (1) the fossil fuel intensity of transport (42%), (2) long travel distances (17%), (3) the state of public transport infrastructure (16%), (4) congestion (15%), (5) population density (10%), and (6) electrification of transport (10%). We explore these top six choices in greater detail in the rest of the paper. Interestingly, items such as costs and affordability, energy or transport efficiency, consumer knowledge and awareness, and automobile accidents were mentioned by only 3% (or less).

Table 1: Most frequently mentioned transport challenges by interviewees (n=227)

No.	Challenge	Example of sub-themes or sub-challenges	Number of respondents	Percentage of sample
1	Fossil fuel intensity / climate impact	Mismatched government policies that still support fossil fuels, GHG emissions, priority for other areas (e.g., electricity, heat), unviability of substitutes such as biofuels	96	42.3%
2	Long distances	Long distances, bad weather, rural areas, inclement weather, freight, and leisure and vacation trips	39	17.2%
3	Public transport infrastructure	Poor public transit infrastructure in some areas, unavailability or unaffordability of light rail, subway, tram, and bus lines, poor planning	36	15.9%
4	Congestion	Congestion, traffic jams, too many cars, long commuting times, road anxiety or road rage	34	15.0%
5	Population density	Low population density, a preference for energy-intensive cars (e.g. SUVs)	23	10.1%
6	Electrification of transport	Electrification of passenger transport, electrification of freight transport, electrification of rail (in Denmark), electric vehicle charging infrastructure	22	9.7%

Source: Authors

Figure 1: Overview of Forty-Four Transport Challenges Identified by Expert Interview Respondents (n=227)



Source: Authors.

Furthermore, Table 2 highlights how experts, besides exhibiting a shared high interest (but still differing) in the challenge of climate change and fossil fuel intensity, identify different transport challenges as important pending their backgrounds and interests. For example, a higher share of those working on energy and electricity or electric vehicles and charging see the electrification of transport as a challenge than the other groups; most of whom see it as a solution. And vice versa, traffic congestion is seen as a challenge by transport and investment experts, but not for interviewees with an energy background, and especially not for those with an environmental background (who see it as a trigger for shifts to more environmental friendly transport modes). Among the latter, the over reliance on (private) cars was somewhat of an issue, which of course was not the case among EV and EV charging industry experts working to offer a cleaner alternative for those cars, not reduce their use. Thus confirming once more Miles' law from politics and public administration that "where you stand depends on where you sit" (Miles, 1978).

Table 2: Most frequently mentioned transport challenges by focus area of interviewee (n=227)

	Transport, logistics or planning (n=73)	**Energy or Electricity (n=63)**	**Funding or Investment (n=10)**	**Environment or climate Change (n=12)**	**Fuel statistics, (non EV) car technology (n=22)**	**Other (n=13)**	**EVs and charging industry (n=34)**
Fossil fuel intensity / climate impact	36%	48%	40%	50%	55%	31%	41%
Long distances	16%	22%	20%	25%	9%	31%	6%
Public transport	22%	14%	20%	25%	5%	23%	6%
Congestion	22%	6%	30%	0%	18%	15%	15%
Population density	10%	13%	20%	0%	9%	15%	6%
Electrification of transport	5%	16%	10%	8%	5%	0%	15%
Road infrastructure	12%	11%	10%	0%	5%	15%	6%
Over-reliance on cars	12%	6%	10%	25%	5%	8%	0%
Heavy duty transport	5%	8%	0%	8%	18%	0%	9%
Topography and/or geography	5%	6%	10%	8%	0%	0%	3%

3.1 Fossil fuel intensity of mobility

Phasing out fossil fuels, often for reasons of climate change or a cleaner environment, was the most frequently mentioned challenge across the expert sample by far. It was mentioned by almost half of all respondents, with many offering more than one or two reasons within this overarching challenge.

For instance, R30 noted that:

> *In Sweden, being fossil fuel-free, that's the biggest challenge. It comes down to carbon emissions. Our primary goal is to cut carbon emissions.*

R91 added that:

> *It is rather obvious that the major challenge is the Danish goal to be a low emission society in 2050. You can say that transport has been more or less steady for 20 years or something like that. It is very difficult because the demand for transport has a tendency to increase with economic wealth. And that very strong driver has to be counterbalanced.*

R113 stated that:

> *The main challenge I would see is how to make all of this transport sector in Denmark less harmful for the environment, having a huge effect on the carbon dioxide balance.*

R56 in Sweden stated that:

> *Reduce carbon emissions. That's the one and the only priority. Number one. First.*

R134 was even more succinct:

> *Emissions reduction is the main challenge in the transportation system.*

Thus, a focus on fossil fuels and the environment clearly weighed heavily on the minds of respondents.

Some respondents went into more elaborate reasons as to why fossil-fuel intensity represented such a pernicious challenge. One explanation was that so far policymaking attention has focused on other sectors. R38 stated that:

> *In Sweden, the fossil fuel intensity of the transport sector is the largest and remaining challenge. Because our residential sector is almost fossil free. We have district heating, which is to a large extent, fueled by biomass or bio-waste. Electricity generation is historically half hydro and half nuclear. Now we see a growing share of wind and bio power. So our electricity and residential sectors are fine. Then the industry that uses a lot of coal is the steel industry, but that is for industrial purposes. The largest remaining obstacle is therefore fossil fuels and the transport sector.*

R91 in Denmark noted that:

> *Since all the other sectors have been lowering their emissions, transport has become more dominant in the whole picture.*

This approach makes some degree of sense to total decarbonisation, especially if it was intended to be sequential – one can first find easier alternates to fossil fuels in electricity supply and buildings before moving to transport.

But respondents also suggested an additional element to fossil fuel divestment was lack of policy and regulation, or a dearth of planning. As R105 put it:

> *Over half of the carbon emissions when we passed 2017 is from transport. So it is the biggest challenge, and when we are looking at transport, the biggest contributor is private driving, private cars. And of course they're not regulated by the municipalities.*

Coupled with this is an unplanned but very much growing demand for mobility, as well as more cars. R37 in Sweden noted that:

> *The most obvious challenge is one about sustainability and climate. We have expanding transportation systems, and the volumes are growing too, with a greater demand for mobility. Yet we also have a strategy to reduce that and go down to zero emissions in 2045.*

R85 in Denmark said that:

> *We are not really seeing a transition going on towards low-carbon transport. We are still based more or less in the same technologies and we have seen a very strong increase this year in auto ownership and, so transport's share of emissions and climatic impact is not going down, it's still going the wrong way. It is still eating a bigger and bigger share, even though you can say fuel consumption from transport has not increased at the same rate, actually has been flat for some years. So we really have a big challenge to more or less transform everything in our transport system towards a low carbon future.*

Some places, demand for cars is even driven by tourism. R13 commented that:

> *Here in Iceland, we will increase the number of tourists, but the carbon dioxide footprint of doing that is not so small. People now fly much more frequently from Europe or America to Iceland, and Icelanders are taking more holidays in places like Paris, France or London, England. These trips used to be once in a lifetime; now they are once a year. That means various transport systems in Iceland—automobiles, boats, and aviation—are a bigger part of the tourism industry, and have a higher carbon dioxide impact.*

These comments all underscore the interconnected nature of fossil fuel dependence with other transport challenges.

A third and final element of this challenge is specific technical challenges with some substitutes, such as biofuel. R140 in Finland noted that:

> *Decarbonizing the private vehicle fleet is the challenge, it will be tricky because our strategy is based on biofuels, and for the near future, the oil price will not increase in ways that make biofuels more profitable. So there will be a demand and need for a lot of subsidies in that field and it's also unsustainable. The criteria are becoming harder and harder, so if you're using biomass for biofuels there can be problems in, at the EU level, so it's not as sustainable as maybe as thought a few years ago.*

Indeed, we will explore more on the challenges to another technical solution, electrification of transport, more in section 3.6.

3.2 Long travel distances

The second most frequently mentioned transport challenged was spatial or topographical: long travel distances, especially between urban and rural areas. As R176 answered bluntly to our question: "*Distances, distances, distances*."

Interestingly, it was respondents from Finland and Norway that voiced this concern the most robustly. In Finland, R133 from Helsinki stated that:

> *Finland is still a sort of a long country, people live quite separately here and there, the distances between cities are rather long, there's an abundance of roads, very long roads, which have been built over the past hundred years.*

R144 from Helsinki concurred and noted that:

> *The challenge is the size of the country related to small population. We have plenty of distance between different places, where people live and were they go to work. Of course we have some larger cities like Helsinki, Tampere, Turku and Oulu, were we have this this urban transport and short distances. But people in Finland they move a*

> *lot. The average distance between work place and living places is over 20 to 30 kilometers.*

R124 said that long travel distances were only exacerbated by bad weather. As they noted:

> *Inclement weather and long distances implicate each other. We have learned that in Finland, nothing works in the wintertime. It will take you twice as long to get anywhere.*

R119 noted that annual leave and vacations only worsen this problem. As they remarked:

> *People have their roots in other parts of the country and they want to go there, and take these very long trips on holiday.*

Thus, a combination of long distances, inclement weather, and a strong commitment to traveling while on vacation contribute to this challenge. Combining these challenges with the aforementioned main challenge of decarbonization of transport, it is clear that future transport options must meet several difficult criteria simultaneously, balancing concerns of emissions with the technical and financial ability to conquer the Nordic's long distances.

In addition to Finland, the long travel distance challenge was also mentioned frequently in Norway. R189 in Norway supposed that:

> *Norway's challenge is a mix of simple geography, long distances, and sparsely populated areas. That is why we rely on aviation to many remote places. Sadly the railway systems that could offer a carbon neutral alternative are somewhat rundown or even at capacity. And then, the alternative mode which could be coastal, short sea shipping, has some big structural challenges in terms of affording the transition to newer ships, with new propulsion systems.*

R196 said that:

> *Generally, in Norway it takes a long time to drive different distances and even short distances over rough terrain require alternate routes around. With regard to public transportation it's also very costly to build out trains and rail, due to mountains and fjords.*

There is therefore a commonality between Finnish and Norwegian experts on the distance travel challenge. However, as R196 implies, Norway faces additional challenges that other Nordics do not, which is their topography. All of the 11 experts that discussed topography or

geography as a transport challenge were Norwegian, which further exacerbated Norway's problem of connecting long distances.

R58 in Sweden adds that the long distance problem affects not only private car use, and indeed, the lack of scrutiny for individual transport and long distances potentially gives credit to the train infrastructure for the country. However, Sweden faces the long distance challenge in a different sector, as there is a freight dimension as well. As they clarified:

> *Sweden is rather a big country if you measure it from south to north its long distance, and we have a lot of goods that has to be transported between the different cities. Most of that now, goes by truck and some by train of course, but mostly it goes by truck and all the trucks are going with the diesel engines. Almost every truck does that now. And that's a big challenge to change that to another fuel.*

R128 from Helsinki noted that Finland also faces challenges with heavy transport in terms of long distances:

> *Well the greatest challenge is probably that Finland is a large country, but still we have a disparity of population, we have most of the population in the south. We also have people living far away from the cities, resulting in extremely long distances between people in sparsely populated areas. Furthermore, we are on the edge of Europe. Practically we are an island, we do not have any railroad or good roads to go to outside of Finland, so these long distances mean we rely heavily on sea transport.*

In this way, distances affect other transport modes including aviation, freight, and marine transport.

3.3 The state of public transport infrastructure

The third most frequently mentioned challenge within the sample related to the need to improve public or mass transport infrastructure, was mostly meant as publicly available light rail, subway, tram, and bus lines. R47 from Sweden put it this way:

> *I see the biggest challenge as making the public transport and train system work much better than it does today, with less disturbances and so on, to make sure that people can rely on the train system. Because we used to have a really good train and rail system, but nowadays there are too many faults, meaning people get stuck in the train and so on.*

R88 in Denmark agreed, and stated that:

> *Of course I would hope that more people would use public transport. I think that is one of the biggest challenges, improving public transit.*

R120 in Finland concurred when they noted that mass transit was especially difficult outside of urban areas:

> *Government, municipalities and cities are looking at to build the infrastructure for public transport, but it is difficult. We have a lot of metro construction going on and there is the planning to build a new fast tram system. Helsinki has it and Tampere has it. I think that is a major challenge, to move people from private cars onto public transport in these areas where it is possible but not everywhere. Finland is very much rural areas and there are no possibilities to build the public transport so people need the private car.*

And R196 in Norway stated that:

> *With regard to public transportation, it is very costly to build out rail networks and trains, and due to mountains and fjords and all this, and also distributed living patterns. So, people often choose to travel by plane across Norway. More locally, public transport offering is often not as good as it should be, and often a bit too late and unpredictable, and also the reason why people choose to take their car instead.*

Thus, availability, affordability, and convenience all play a role in expert perceptions of public transport. As the public transportation sector continues to face these challenges, consumers may become overly reliant on personal transport and cars.

Some respondents framed lack of investments in public transport as a legacy issue rooted in poor planning and property rights, dating back years or even decades. R148 in Finland explained it by noting:

> *Reduction of personal cars is key and would by motivated by more public transport or shared vehicles. Yet the whole ownership thing is difficult to overcome. The issue is also related to the structure of the cities, Finland has excellent American-style cities which are very fun to drive around in your old car. In other words, Helsinki, Tampere and other cities are now just moving into the phase where they kind of realized that "ok maybe the development that we have done in the past 20, 30 years is not leading to sustainable cities practice and structure, but living without your own car is difficult – we need public transport investments.*

Other respondents noted that improving infrastructure and making investments in public transport required not only large financial investments, but resulted in annoyance and disturbance. R143 in Finland cautioned that:

> *In the Helsinki region, we are concentrating on better rail and tram connections, but this system needs feedlines and buses, and all of that requires revenue to build and maintain, and also take years to plan and build.*

R90 in Denmark supposed that:

> *We have infrastructure in terms of trains, that is insufficient because there has not been any significant investment in years. That means that politicians speak about 'you should take the train not the car', but there is no capacity in the train and it will take years and billions of Danish Kroner before its up and running.*

Yet, even when initiatives for public transportation are been implemented they have lacked vision and planning capacity, as R107 noted how in Denmark a new tram line was tearing up the city. As they said:

> *In Aarhus we are building this light rail as a form of public transport. And it's super unambitious, it's destroying the whole city for years and once it's done, I mean it's not really that great. It's going to the hospital, that's it, and nationally we lack a visionary plan for public transport, like trains, which should be super easy, because we are like the most easy country in the world, we have bridges, it's really flat, so lack of ambition in public transport is a major barrier.*

Indeed, Figure 2 shows construction of this light rail system in Aarhus, and how necessitated the closure of many main roads. In many respects, it seems that public transport cannot prosper or even coexist with the dominance of the personal car in the Nordics, with half-measures like the light rail system in Aarhus being adopted as a compromising measure.

Figure 2: Construction of Light Rail Tram in the City Center of Aarhus, April, 2017

Source: Authors

R166 from Finland even commented that it was sidewalks and bike lanes that made more public transit difficult:

> *There is one peculiar characteristic in Oulu that makes difficult to develop public transportation: an abundance of pedestrian and cycle roads. There is 1,500 kilometers of cycle roads in Oulu, a massive amount of bicycles, even in the winter. It competes with public transport, and makes it unprofitable.*

Hence the seriousness of this transportation challenge: growing demand for transport and mobility yet competition between options (competition for funds), with city planners favoring walking, bicycling, and then public transport, and lastly cars, yet politicians and other short term focus favoring cars and asphalt. Against this competition exists a background of existing city blocks and corridors as well as uncertainty about the right type of technology or transport modality.

3.4 Congestion

With a growing demand for mobility and the challenge how to invest in additional or alternative modes of transport, another challenge surfaces of congestion. Congestion—usually congestion or traffic jams caused on roadways or highways by private cars—was mentioned as another recurring and growing challenge, often worsened by the lack of progress in public transportation options. For many experts, congestion was a key challenge to the transport system, and one that was only increasing due to accelerating travel demand and rising populations. The congestion issue therefore touches upon four dimensions: loss of valuable time, increased frustration, and then potential safety as well as environmental impacts such as pollution and carbon emissions.

For example, R37 in Sweden in Norway stated that congestion and reducing demand is "the key challenge":

> *The key challenge is reducing the growth of transport volumes, and reducing car traffic, at least in the major towns.*

Even in Iceland, congestion was becoming a major challenge, as R28 states:

> *Parents are dropping kids off in the car now, and that's a big problem here in Iceland. There is a huge traffic jam around all the schools in the morning.*

And R16 adds:

> *We see transport and congestion problems arising now that we have this boom in tourism. Tourism has been growing annually at rate of something like 30% every year over the past three or four years. A trend in tourism is that many visitors come here and rent a car, and drive out around the island and around, especially to popular areas such as the geysers or the waterfalls. We've thus seen a 100% increase in traffic on some days.*

However, given its important influence on the Icelandic economy, reductions in tourism remain unlikely, just as morning and evening commuters in the rest of the Nordics are part of a broader economic strategy. This comes with certain costs; time, frustration, safety and, of course, emissions. The most obvious costs of congestion were demonstrated as

a loss of valuable time and frustration. As R168 stated, the increasing congestion in Oslo caused him personally to lose time, both personally and professionally:

> *Increasing traffic is the biggest challenge for Norway, […] everyone is moving into Oslo and most of the businesses are connected to Oslo or nearby. For the last decades, the rush in the morning it's just been moving further and further out. You have to get up bloody early to avoid the rush, or else you get stuck in traffic taking the kids to school, going to work, and coming home. It makes it so you can't cope up with your private life because you spend too much time in traffic, too little time at home, and you also spend too little time at work, so it doesn't add up, so to say.*

More quantitatively, R173 calculated that time lost due to congestion was the single highest cost to Norway associated with personal transport (higher than accidents, health emissions and climate change damages):

> *I would say that if you look at the costs to society related to transportation the two main costs are congestions, because that's very time consuming and time is money, as you know, so that is according to when you really investigate this, this is the largest cost to society, that is congestion.*

Beyond losing valuable time, R79 from Denmark added that frustration was also escalating:

> *Well traffic is a big problem, we have an infrastructure that is not able to cope, in some places congestion is becoming a real problem and were getting short of space for roads. People are on the highway on the road to Copenhagen during rush hour is miserable.*

Moreover, congestion can pose more problems than just lost and frustration, as R49 in Sweden argued that it can also be a safety issue:

> *Transportation wise, congestion is a big thing in big cities. It is all relative because if we have a traffic jam in Gothenburg, it's nothing compared to other cities in Europe or globally. But still, congestion is a cause for frustration, and could be serious as well if you are talking about ambulances as well.*

Beyond hypothetical safety issues, other respondents noted, congestion is also linked to other pressing concerns such as climate change and the environment. R94 stated that:

> *Personally, I spend twice the time to go to work in the morning compared to 5 years ago, due to congestion. Then you can only start to imagine the carbon dioxide emissions from that.*

R99 noted that:

> *Even in Denmark, we are facing congestion issues the same as many other cities. In Copenhagen, congestion is a major problem and it impacts pollution flows of particulate matter and acid rain and also carbon emissions.*

In spite of the various costs listed above, R73 in Denmark lamented that, unlike other places in the world, there has not yet been any action taken to resolve congestion:

> *In California, you introduce these policy instruments or incentives because you have such problems with congestions and pollution, so that's, acceptable in the population to make these thing when they can see that really disturb their every day, their way of living, so but, we are not really at that level in Denmark. But that time may come soon, since every month a thousand or more citizens move to Copenhagen, so Copenhagen is congested. Traffic jams just get worse and worse.*

Indeed, the interview data suggests that many of the central transport challenges in the Nordics are highly interconnected. The quality of public transportation obviously affects the prevalence of private car use and thus congestion, and both face the challenge of satisfying the criteria of reaching long distances and concomitantly reducing carbon emissions. Implicit in this conclusion is that transport policy must be done in a compressive systematic approach, as opposed to piecemeal policy that will fail to address the interconnected issues presented above.

3.5 Population density

In addition, population density also was frequently described as a challenge where high density was related to larger cities and iterated with the congestion challenge described above, and low density being commonly framed as a consequence of the aforementioned challenge of long distances and rural areas in the Nordics.

For example, R43 in Sweden saw these two challenges as connected:

> *The essential transport problem for Sweden is that it is a big country, large with quite a small population.*

In that thread, R160 claimed the disconnectedness of cities and low population in between in Finland led to a reliance on personal transport:

> *Finland has a small amount of people, we have a population of only five million people, so in rural areas, we still need private cars.*

Correspondingly, as R169 argues, the low populations and large distances also decreased the feasibility of public transportation, given that the capital cost investments of public transportation would be split across a smaller amount of people, as compared to other countries:

> *The average dividend on transport investments in Norway is very low. It has to do with the fact that we are a sparsely populated country, meaning that the benefit accrues not to so many people as for instance in Germany or the Netherlands. We are also a very expensive country to build roads and railways in.*

Sparsely populated rural regions only accentuate the interconnected challenges above of resolving fossil fuel intensity and long travel distances while promoting public transportation or alternative vehicle choices. As R005 in Iceland stated:

> *In our point of view [the challenge] is getting more economical vehicles on the road, but still [] … we have snow here, we* have to *have 4x4 vehicles. So we are in a little bit of a dilemma because we want to lower CO2, but we can't, because as soon as you go out of the Reykjavik area you need 4x4 in the winter time.*

Besides the type of vehicle (4x4, SUV, etc.), the technology behind the vehicle was also discussed, especially in relation to electrification indicating that the choice of alternative technologies comes with its own challenges, as discussed below.

3.6 Electrification of transport

For, though it may be a possible solution of some of these above challenges, the electrification of transport—promotion of electric vehicles—was also characterized as another enduring transport challenge itself.

R13 put it succinctly:

> *The challenge is to electrify transport in Iceland.*

In Sweden, while R39 noted the importance of electric vehicles, this energy expert also stated skepticism in the temporal feasibility of such a transition:

> *To create infrastructure for electricity fuels in [the] countryside, that is the challenge. I don't think it is possible at all, at least in our lifetime.*

R80 in Denmark argued that:

> *The greatest transportation challenge is the electrification of transportation, because there have been several occasions where we have discussed electrification and how to deal with the greenhouse gas targets for Denmark. So the biggest challenge is how to get transportation electrified, that's the main one.*

In Finland, R130 acknowledged that a considerable amount of work remains for electrification:

> *Finland needs at a minimum 250,000 electric vehicles by the end of 2030, which we have a long way to go. Last year we sold only 222 electric vehicles in Finland in total, all brands included.*

And while substantial progress in Norway has been made in terms of electrifying personal transport, R203 maintained that electrification is still the central transport barrier:

> *The main challenge in Norway is to go from fossils to electric. To create the grid infrastructure and charging infrastructure. That is maybe the greatest and biggest challenge today.*

The electrification challenge is therefore equally prevalent in all five Nordic countries.

Some respondents suggested that such electrification should extend well beyond the domain of personal light duty vehicles or cars. R40 declared that:

> *The challenge is to accelerate the uptake of electric vehicles. It is good for Sweden because we have a surplus of electricity and low carbon emissions from our generation. Also, we can achieve more quiet cities, less noise and no local emissions. So we will reach several environmental targets if we fully go for electric vehicles that includes buses and trucks and distribution.*

R103 added that:

> *The great general transportation challenge would be the transformation from fossil-based transport to electric transport. And especially into the heavy-duty area, like trucks and buses, and also of heavy highway vehicles. We have a marine sector too, but the marine sector has already started the transformation towards electrification. So might that actually happen.*

While electrification may help assuage some of the five previous transport challenges, like decreasing fossil fuel intensity, other challenges like the long distances may increase the difficulty of electrification. However, as R202 remarked, while electrification is a solution to some of these challenges, it is not a solution to all of them:

> *So, both from an energy perspective, but also from a cost of operation perspective [electric] vehicles, if not yet, [then soon] will have lower costs to operate. So that is of course some kind of importance. Then of course you then also need to be aware [] that if you buy new technology and take out the cost, and can reduce the price for people to buy mobility, they would buy more. [] That would potentially give the society an increased cost in terms of congestion if you are not aware of that and mitigate it with smart new policies. And you can see that in Norway.*

In other words, electrification may not impact, and indeed, may worsen the congestion crisis in the Nordics, particularly with the increase of use and ownership of private modes transportation.

4. Conclusion and implications

Our sample of 227 expert interviews in the Nordic region suggests that the transport challenges facing Denmark, Finland, Iceland, Norway and Sweden are heterogeneous. The fossil fuel intensity of transport was mentioned most frequently as a challenge, but five other challenges were also identified most frequently across the interview sample. The combined six challenges—fossil fuel intensity, long travel distances, the state of public transport infrastructure, congestion, population density, and electrification—may serve as a useful short list of priorities for transport planners and policymakers.

Interestingly, however, is that some of these six priorities reflect underlying causes or drivers of inefficiency or lack of mobility, such as long distances or population density or declining public infrastructure quality. Others deal with problems or externalities, such as climate change and fossil fuels or traffic congestion. Still others relate to recommendations for the future, such as the electrification of transport. Furthermore, within the sample some challenges were more prioritized in certain places. As Table 3 indicates, in Iceland, Norway, and Sweden, fossil fuel intensity was mentioned the most frequently. In Denmark, it was fossil fuel intensity and congestion. In Finland, it was longer travel distances. Table 2 also noted (above) how preferences differed meaningfully by the occupations of respondents, with

those in transport, engineering, or finance prioritizing issues such as traffic congestion, but those with an environmental background prioritizing issues such as low-carbon innovation and more sustainable transport modes.

Table 3: Nordic transport challenges weighted by country in terms of frequency

	Iceland (n=29)	**Sweden (n=42)**	**Denmark (n=45)**	**Finland (n=50)**	**Norway (n=61)**	**Total (n=227)**
Fossil fuel intensity	24% (n=7)	50% (n=21)	51% (n=23)	34% (n=17)	46% (n=28)	42% (n=96)
Long distances	0% (n=0)	7% (n=3)	0% (n=0)	36% (n=18)	30% (n=18)	17% (n=39)
Public transport	3% (n=1)	7% (n=3)	11% (n=5)	26% (n=13)	23% (n=14)	16% (n=36)
Congestion	10% (n=3)	10% (n=4)	31% (n=14)	4% (n=2)	18% (n=11)	15% (n=34)
Population density	0% (n=0)	5% (n=2)	0% (n=0)	18% (n=9)	20% (n=12)	10% (n=23)
Electrification of transport	7% (n=2)	12% (n=5)	9% (n=4)	12% (n=6)	8% (n=5)	10% (n=22)

In addition, the six challenges we discuss in detail interconnect in numerous ways. The challenge of traffic congestion leads to more harmful carbon emissions. Yet, it is also connected to population density, where growing cities such as Copenhagen and Oslo continue to attract more people, and may therefore resulting changes to emissions profiles (which can be positive or negative). The electrification of transport is connected with phasing out fossil fuels; same with better investments in low-carbon public transport, which can play a role in achieving national environmental and climate goals. Long distances also intersect with low population density, public transport, and the need for a sufficient volume of passengers to make public schemes profitable, especially in hard to serve rural areas or smaller cities such as Oulu, Finland or Herning, Denmark. Population density and long travel distances also both implicate the electrification of transport – it is hard for electric vehicles to fully substitute for cars given their current range, and difficult to place charging infrastructure everywhere. The state of public transport connects with fossil fuel intensity as well; as one example, trains in Denmark are still almost entirely diesel powered. These interconnected and synergistic attributes strongly suggest that the Nordic region's transport challenges are interstitial – and

that they are also comprehensive, and not prone to a single solution or policy mechanism. As such, policymakers are encouraged to think more comprehensively when formulating policies to resolve any of the abovementioned challenges.

Lastly, while the six most mentioned challenges serve as a useful short-list, what is also noteworthy is what was infrequently mentioned or under-discussed. The six challenges discussed here fall roughly into environmental, spatial, or infrastructural dimensions. We have environmental concerns such as phasing out fossil fuels for climate change, or the electrification of transport. We have spatial concerns such as long travel distances and population density. We have infrastructural concerns such as the state of public transport and congestion. However, other issues were mentioned less frequently. Better incentives for smart or automated or autonomous vehicles was not a popular concern among experts, nor were addressing demographic attributes such as types of users, gender issues, and consumer awareness and education, when referring to the main transportation challenges. Financial concerns such as innovation and transport, or business models for mobility, were not popularly discussed. Similarly, social justice, equity, and public health concerns were rarely mentioned, including deaths from car crashes, a significant cause of morbidity and mortality in all five countries examined. Thus, our short-list of challenges is not meant to be absolute or all-encompassing: it illustrates the complexity of the region's transport challenges, made all the more salient when one considers the full range of 44 distinct obstacles mentioned by our expert respondents.

5. Appendix I – Overview of Semi-Structured Research Interviews

Country (5)	***Cities (17)***	***Interviews (227)***	***Dates (9 months)***
Iceland (n=29)	Reykjavik	1-22, 29	Sept/Oct 2016
	Akureyri	23-28	Sept/Oct 2016
Sweden (n=42)	Stockholm	30-43, 66-68, 70	Nov 2016
	Gothenburg	44-61	Nov 2016
	Lund and Malmo	62-65, 69, 71	Nov 2016
Denmark (n=45)	Other*	72	Jan 2017
	Greater Copenhagen Region	73-100, 113, 115	Jan/Feb/Mar 2017
	Aarhus	101-102, 104-107	Feb 2017
	Other*	103	Feb 2017
	Aalborg	108-112, 114, 116	Feb/Mar 2017
Finland (n=50)	Greater Helsinki region	117-144, 154, 163	Mar 2017
	Tampere	145-153, 155, 164	Mar 2017
	Oulu	156-162, 165-166	Mar 2017
Norway (n=61)	Greater Oslo region	167-208	Apr 2017
	Trondheim	209-220, 222	May 2017
	Tromsø	221, 223-227	May 2017

* Two Danish towns are not mentioned by name for anonymity of interviewees.

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